Response to H1N1 in a U.S.-Mexico Border Community

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Public health experts from a county health department and a school of public health collaborated to establish a simple, functional surveillance system to monitor swine-origin influenza virus as it crossed from Mexico into a Texas border community during the 2009 pandemic. The draft national and state preparedness plans were found to be cumbersome at the local level, so a simple, more practical real-time surveillance and response system was developed, in part by modifying these documents, and immediately implemented. Daily data analyses, including geographical information system mapping of cases and reports of school and daycare absences, were used for outbreak management. Aggregate reports of influenzalike illness and primary school absences were accurate in predicting influenza activity and were practical for use in local tracking, making decisions, and targeting interventions. These simple methods should be considered for local implementation and for integration into national recommendations for epidemic preparedness and response.

Recent efforts to prepare for influenza pandemics have been driven by the emergence and spread throughout Asia of a highly pathogenic avian H5N1 influenza strain in wild birds and domestic fowl.[1-3] This avian virus does not transmit easily from human to human, but it has killed more than half the people who were directly infected from poultry, thus raising the specter of the 1918 H1N1 pandemic.[4-6] That catastrophic pandemic killed more than 40 million people worldwide.[4,7] In the spring of 2009, the ever-unpredictable influenza surprised experts and the world by emerging as a novel H1N1 influenza A strain in Mexico.[8-10] In spring 2009, the virus was designated as a swine-origin influenza virus (2009 H1N1) to distinguish it from other H1N1 viruses currently or formerly circulating. It is now commonly called 2009 H1N1.

Cameron County is on the U.S.-Mexico border in the southernmost tip of south Texas, and it was among the first places in the United States to experience the arrival of 2009 H1N1. The population of 392,738 is distributed over 905 square miles (http://quickfacts.census.gov/qfd/states/48/48061.html). It is the closest U.S. geographic region to the place where the 2009 H1N1 virus originated, which was to the south in the city of La Gloria, Veracruz, Mexico.[8,11] It has 4 heavily trafficked international border crossings.[12] On April 24, 2009, county officials were alerted to 26 cases of influenzalike illness in Brownsville health clinics. On April 29 an infant from Mexico City became the first 2009 H1N1 death in the U.S.[13] He had been visiting family in Cameron County and had fallen ill there after returning from a brief visit to Houston. The timing of his travels and onset of disease suggested infection in Cameron County. At that moment Cameron County became, briefly, the epicenter of the U.S. epidemic. Attention was further intensified when, on May 4, a pregnant woman in Cameron

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County became the first U.S. citizen to die from complications of 2009 H1N1 infection.[14]

The impact on the county and the community was considerable, and the burden of work required in order to implement national and state response guidelines was highly problematic. This article details the lessons learned in using the national guidelines and the steps taken to effectively respond to a local emergency and to establish a simple, functional surveillance system to measure and mitigate the impact of 2009 H1N1 as it crossed from Mexico into a Texas border community.

Methods

Standard Influenza Pandemic Response

The initial response of the Cameron County Department of Health and Human Services (CCDHHS) to 2009 H1N1 followed the Texas Department of State Health Services Pandemic Influenza Plan Operational Guidelines.[15] This document, in draft form at the time of the outbreak, established the Texas Department of State Health Services (DSHS) Central Office in Austin as the primary coordinating site for pandemic flu emergencies, followed by the regional and county or city offices. The underlying assumption of this document was the need to prepare for an influenza pandemic originating from "high-risk areas overseas." These plans assumed the epidemic would have already met World Health Organization Pandemic Level 6 criteria, the level on the WHO scale that denotes that a global pandemic is underway.[15,16] Based on past experience with the progression of epidemics, 3 months or more would have elapsed between the first discovery of a new pandemic strain and the establishment of an epidemic in Texas. In fact, epidemic influenza was first detected in Cameron County on April 24, only 5 weeks after the new influenza outbreak was first reported from Mexico.[17]

Surveillance for Suspected Influenza Cases

The Cameron County health department and the Brownsville campus of the University of Texas School of Public Health jointly adapted existing national and state preparedness plans to develop and implement a simple, practical, real-time surveillance system. Simplified data collection and timely analyses, including geographical information system mapping (GIS) and reports of school and daycare absences, were used for outbreak management.

The initial public health response focused on identifying individual cases of influenzalike illness (ILI) and following up to confirm the presence of 2009 H1N1 among people in the community who were ill. In accordance with Centers for Disease Control and Prevention (CDC) guidelines, an ILI case was defined as a person with a temperature equal to or over 100°F and a cough or sore throat or both.[18] On April 26, Cameron County faxed state- and DHS (Department of Homeland Security)-supplied instructions and data forms for reporting cases of ILI, instructions and specimen collection kits, and recommendations for treatment of cases to local physicians and hospitals. Physicians were instructed to obtain nasal or nasopharyngeal samples for confirmatory diagnosis if a patient met the criteria or if the patient had a fever greater than 100°F and had traveled to Mexico within the past 7 days. Rapid influenza diagnostic tests (RIDTs) were also used by many physicians to confirm a case as probable influenza A.[19] However, national, and thus state, guidelines and case definitions for reporting of necessity changed several times throughout the course of the outbreak.[18]

Physicians were instructed to ship specimens to CDC-approved test sites[19]—in this case, the Texas Department of State Health Services laboratory in Austin, Texas. There the specimens were tested for seasonal influenza A viruses. Specimens that were positive for influenza A but negative for the circulating seasonal strains were forwarded to CDC for 2009 H1N1–specific testing. Cameron County officials were advised to interview probable or confirmed cases and to complete a 17-page epidemiologic questionnaire. Within days, this questionnaire was replaced by state authorities with a 3-page version that requested demographic data, a brief medical and travel history, and RIDT results.

Cameron County health staff interviewed ILI-reported patients by telephone to complete the questionnaires. Clinical data, including symptoms and RIDT results also were obtained from medical records. In cases where the patient's self-reported body temperature differed from the clinical medical record, the higher temperature, regardless of day of illness, was recorded. With more than 30% of the population of Cameron County below the poverty level and high school graduation rates of only 51%, the purchase and use of a thermometer is uncommon. Furthermore, by the time patients arrived at the physician's office, many had taken over-the-counter antipyretic medication. Thus, the definition of a case based on actual temperature readings was impractical and may have led to misclassification of patients. Not until July did we have laboratory data from all sources (ie, state, private, and federal) for the period April 30 to June 30. Only at that point were we able to consolidate these data.

Support Measures and Data Management

The labor-intensive follow-up of individual ILI reports in place at the onset of the epidemic required substantial

frontline staff—well beyond the capacity of a small health department. Consequently, county officials requested assistance from the nearby Brownsville campus of the University of Texas School of Public Health (UTSPH-B) and the University of Texas at Brownsville (UTB). Immediately (April 30), volunteers from the university joined county health officials in collecting data and in designing and implementing a system of electronic data management. Information from the surveillance forms was entered into an electronic database created overnight using the web-based survey tool SurveyMonkey (SurveyMonkey.com, Portland, OR). Data were then exported daily to Microsoft Office Excel (Microsoft Corporation, Redmond, WA), reconciled with medical records to ensure accuracy, and subjected to real-time analysis as described below. ILI records were geocoded using ArcGIS (ESRI 2009, Redlands, CA, Version 9.3).

Additional Surveillance

Daily absentee reports were collected and reported from 106 schools (out of a total of 139), 124 child daycare facilities (out of a total of 183), and 7 adult daycare facilities and nursing homes (out of a total of 46). An electronic reporting system was set up, and facilities that were unable to use this transmitted information by fax. Data were analyzed daily to produce epidemic curves and age distributions. GIS maps of the spatial and temporal evolution of the local epidemic based on ILI reports were also prepared daily by geocoding home addresses. These real-time analyses were shared with the community and with medical, political, education, and business leaders and were used each morning to provide up-to-date information to community leaders on which they could base decisions.

Community Intervention

Based on the GIS maps, interventions were targeted each morning to areas showing clusters and/or highest incidence. Interventions included door-to-door visits by bilingual *promotoras* (lay community health workers) who delivered Spanish and English newsletters about the prevention and treatment of influenza. The newsletters were modified from material previously prepared by local authorities in collaboration with UTSPH-B for seasonal influenza outbreaks, and they included advice to not visit emergency rooms or outpatient clinics unless severely ill. The newsletters also communicated information on non-pharmaceutical interventions; they featured local role models making behavioral changes to prevent and manage illness in themselves, their families, and the community. The *promotoras* were also trained to answer questions about the H1N1 influenza using information from CDC fact sheets. Outreach initiatives also targeted large gatherings (eg, church events).

Subsequent Analyses

Data sets from which identities had been removed were subsequently analyzed for logic errors or missing values using Statistical Analysis System software (SAS, SAS Institute, Cary, NC, Version 9.1). Incidence of 2009 H1N1 confirmed cases by age group were calculated from county reports using denominators from the 2007 American Community Survey estimates for Cameron County.[21] We had 4 related sets of data: (1) all reported ILI cases; (2) investigated cases positive by RIDT; (3) cases with laboratory-confirmed 2009 H1N1; and (4) absentee reports from schools and daycare facilities. We analyzed each using time, age, gender, and geographic location to see how well each might predict the evolution of the epidemic in the county.

Confidentiality

All direct contact with patients was handled by the county in accordance with their public health mandate. Analyses of "de-identified" data were approved by the Houston Health Science Center Committee for the Protection of Human Subjects.

RESULTS

Data Entry

The data entry system we developed was adapted in part from the CDC and state response recommendations, but it was greatly simplified to just 29 questions. We entered all ILI reports according to the CDC definition for ILI. The case report took about 14 minutes to enter, and ILI reports took about 12 minutes. School, daycare, and other facility reports required about 6 to 13 minutes. The original 17-page case report took well over 20 minutes to enter. Our updated survey tool therefore allowed daily entry of data on all reported cases using our expanded team of volunteers. We now had 4 data sources (ILI, RIDT, laboratory results, and school attendances) on which we were then able to layer the GIS data for spatial maps. We then used all of these in tracking the epidemic in real time, and we compared their relative usefulness in managing an epidemic at the county level.

Surveillance of ILI

Between April 27 and May 28, the county received 2,209 ILI reports. The assembled team investigated as many individual reports as possible until June 5, when the state reduced reporting to hospitalized, confirmed H1N1 cases. Since we had few ILI reports with body temperatures, we did not include this in the case definition. This change was also eventually made by the CDC.[18] In all, 498 ILI investigations (22.5% of ILI reports) were completed; most of these were the earliest cases in order of receipt of the report. Retrospectively, we were able to determine that, by the time

Figure 1. Timeline of the H1N1 epidemic as it related to events in Cameron County

2009		Event
Feb/March		Influenzalike respiratory disease outbreak in eastern Mexico
March	18	H1N1 virus identified in Mexico
	28	H1N1 virus identified in U.S.
April	15/17	First U.S. cases confirmed
	24	26 suspected cases identified in Cameron County
	25	WHO declares H1N1 a Public Health Emergency of International Concern
	26	U.S. declares H1N1 a Public Health Threat ILI report form faxed to Cameron County health providers
	27	Peak illness onset—Mexico
	29	Death of infant traveling through Cameron County WHO raises pandemic alert from Phase 4 to Phase 5
	30	University of Texas School of Public Health joins CCDHHS to assist with surveillance
May	1	Active surveillance of ILI in schools, daycare facilities begins
	4-9	Peak ILI onset in the U.S.
	4	Several Cameron County school districts reported cases of ILI
	5	Cameron County woman dies (first U.S. citizen) First reports of ILI surveillance received from adult daycare facilities and nursing homes
	13	1,551 cumulative ILI reports received by CCDHHS
	11	WHO declares 2009 H1N1 a Phase 6 pandemic
June	5	State reduces reporting to hospitalized confirmed HIN1 cases
	30	Confirmatory laboratory data collated in Cameron County

the first ILI report was received, the outbreak had already been in progress for nearly a week. We also determined that these first reports coincided with the peak of the local epidemic. Figure 1 shows the detailed timeline as it related to events in Cameron County.

Surveillance Using RIDT

Rapid influenza diagnostic test (RIDT) information was collected on ILI cases where available during investigations, with 404 of 498 (81.1%) ILI cases that were tested reporting positive for influenza A. This provided useful confirmation, despite the variability overall of these tests, that the respiratory illnesses being reported were primarily influenza.

Laboratory Confirmation from CDC

The limited number of specimens tested for 2009 H1N1, the shortage of specimen collection kits, and delays in receiving results created confusion and some skepticism in the community, particularly among health providers. Only 378

cases were eventually confirmed as being positive for 2009 H1N1, most of which were collected well after the epidemic had peaked.

Tracking the Epidemic

The rapid development of the epidemic, the large data collection demands of the national preparedness plan tools, and limited local staff made data collection challenging. However, the modified surveillance system we developed, based in part on this plan, was workable and allowed us to collect and enter key data on a sizeable portion of ILI reports during the heat of the outbreak. The most complete and useful product was the epidemic curve based on ILI incidence, which was updated daily for real-time tracking of the epidemic and was shared with community leaders and institutions (such as schools) as an aid to decision making.

However, there were limitations. Nearly half of all ILI report forms had no date of onset recorded, but for those 498 patients whose charts we reviewed, we were able to retrieve onset dates for nearly 95%. As noted above, tem-

perature records were often missing. The average interval from date of illness onset to receiving the report was 3 days (±3 days). For the 212 cases that had laboratory-confirmed 2009 H1N1 virus infections, the average interval from date of onset to receiving laboratory confirmation was 13.5 days (± 9.8 days). Nevertheless, the accuracy and practicability of ILI surveillance in real-time tracking of the epidemic was confirmed. Figure 2 shows the pattern of the entire epidemic for all 3 measures—ILI, RIDT, and H1N1 confirmation—using only reports where date of onset was available. This shows that the use of the ILI report to effectively track the course and characteristics of the epidemic was substantiated by the laboratory data. Data from RIDT were the least useful.

Tracking the Epidemic Using Spatial Surveillance

We produced daily maps showing the spatial distribution of new cases from the home addresses. We successfully GIS mapped 1,247 (79.8%) of the 1,563 ILI reports received up to May 13, 2009 (Figure 3). We calculated incidence rates from 2000 census data at the census block group level. The highest rates were centered in urban areas, particularly Brownsville, directly on the border. The highest rates within the Brownsville city limits were found in the southern and eastern regions of the urban area. These areas of the city are both closest to the international border with Mexico and known to be the economically less advantaged areas of the city. We were interested to see that the daily spatial data maps confirmed our suspicions by showing that cases first appeared along the border, close to border crossing points (eg, bridges), and subsequently spread north within the county.

Age Distribution of ILI Cases

The majority of reported cases were in the pediatric population. The highest incidence of ILI cases was in the 5-9-year-old group, with no detectable gender differences in reporting (Figure 4). Like other reports in the U.S., these data demonstrate that this was primarily a pediatric outbreak.

Additional Surveillance Methods

The highest number of daily absences came from the 124 infant daycare facilities, followed by the 106 reporting schools. It was not possible to recruit some of the daycare facilities in the time available, and some were not willing to participate. Seven adult daycare facilities and nursing homes reported, and all sites reported less than 1% absenteeism of employees and residents because of illness. Figure 5 shows percent present reports for Cameron County, reflecting the drop in school and daycare attendance that coincided with the epidemic. Local hospitals reported cases directly to the county.

Community Intervention

Based on an examination of the age distribution and spatial analyses, we decided that our messages—specifically, simple methods to avoid infection, including not taking well children to crowded clinics and caring for sick family members at home where appropriate—needed to be targeted to families with school-aged children in the areas most heavily affected. We sent 5 *promotoras* into 3 communities (door-to-door visiting over a thousand households) to promote nonpharmaceutical interventions, including maintaining good hygiene and encouraging families to keep ill children at home. We also met with school superintendents, health personnel from clinics and hospitals, and political leaders to assist in their decisions regarding closing institutions and responding to the epidemic.

DISCUSSION

The ultimate assessment and response burden in an influenza epidemic is borne by county and city health departments. This report shows that the local response can be very effective using simple techniques and good communications. Although it was clear during this recent epidemic that state and national preparation plans recognized the need for a comprehensive response in the event of an influenza epidemic, there was less specific information about how disease preparedness and response for outbreak management would be enacted at the community level.

The ability of Cameron County health staff to respond to the volume of reports and meet the requirements for the national guidelines for outbreak surveillance, management, and follow-up was significantly hindered by the volume of detail requested by the national guidelines and by the limited staff capacity. We have described how local county and academic personnel responded to the demands of the emergency by jointly developing and implementing simple, practical approaches to real-time surveillance. We used these methods of gathering and recording data to quickly establish surveillance and to generate daily epidemic curves, GIS maps, and age-specific incidence in order to provide authorities and the public with a comprehensive picture of the ongoing epidemic of 2009 H1N1.

Our data show that, relative to the other available indicators of disease, such as laboratory confirmations of virus used for national reporting, the daily ILI reports were the best and most immediately obtainable measure of the actual epidemic at the county level. Despite the broad case definition, in the immediate context of the epidemic, the ILI

Figure 2. Cases of ILI (1,169 cases) by level of confirmation. The top graph shows influenzalike illnesses (ILI), the middle graph shows ILI that tested positive for influenza A in local rapid flu tests, and the bottom graph shows confirmed 2009 H1N1 cases. Scales are identical for all 3.
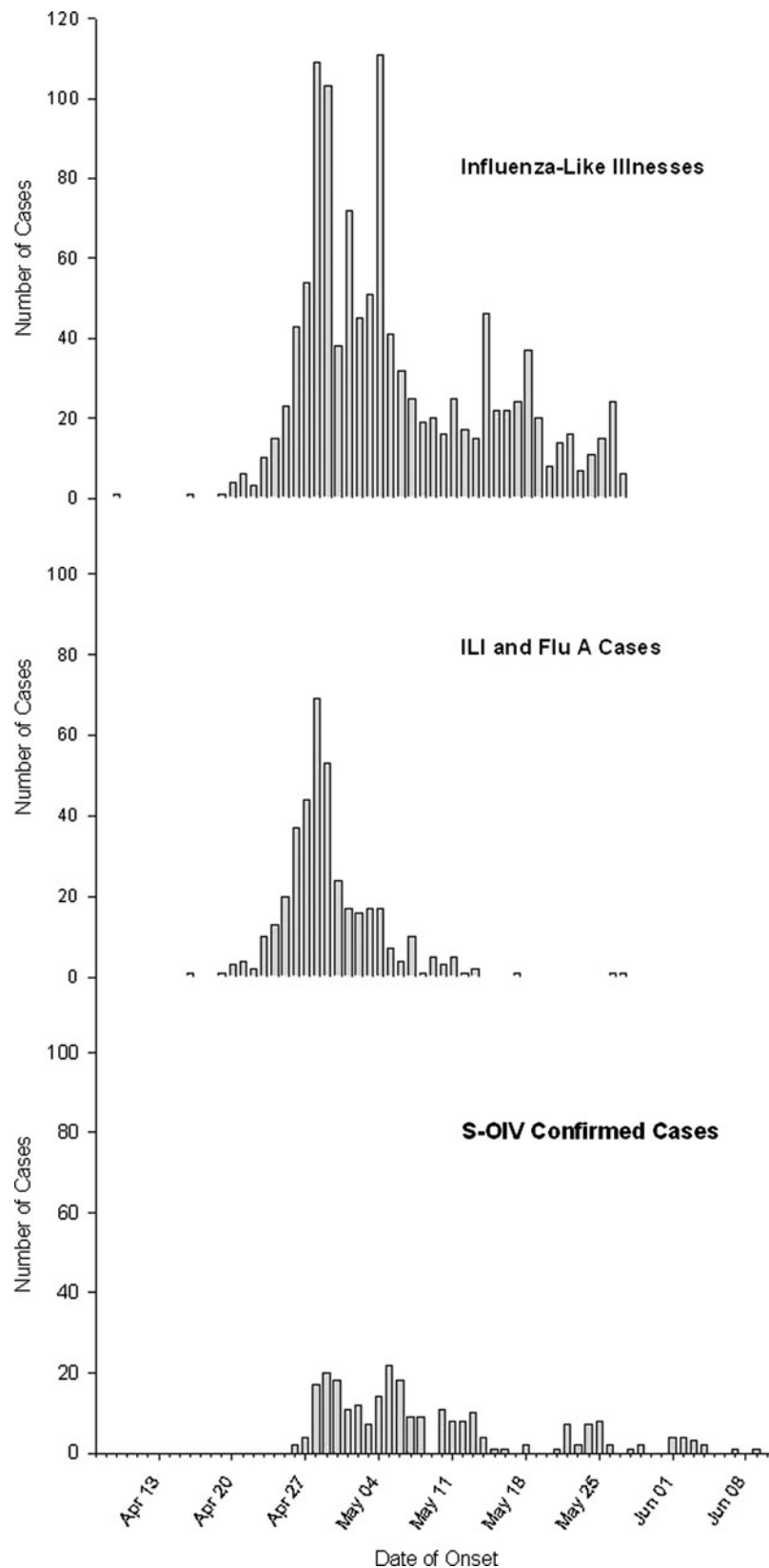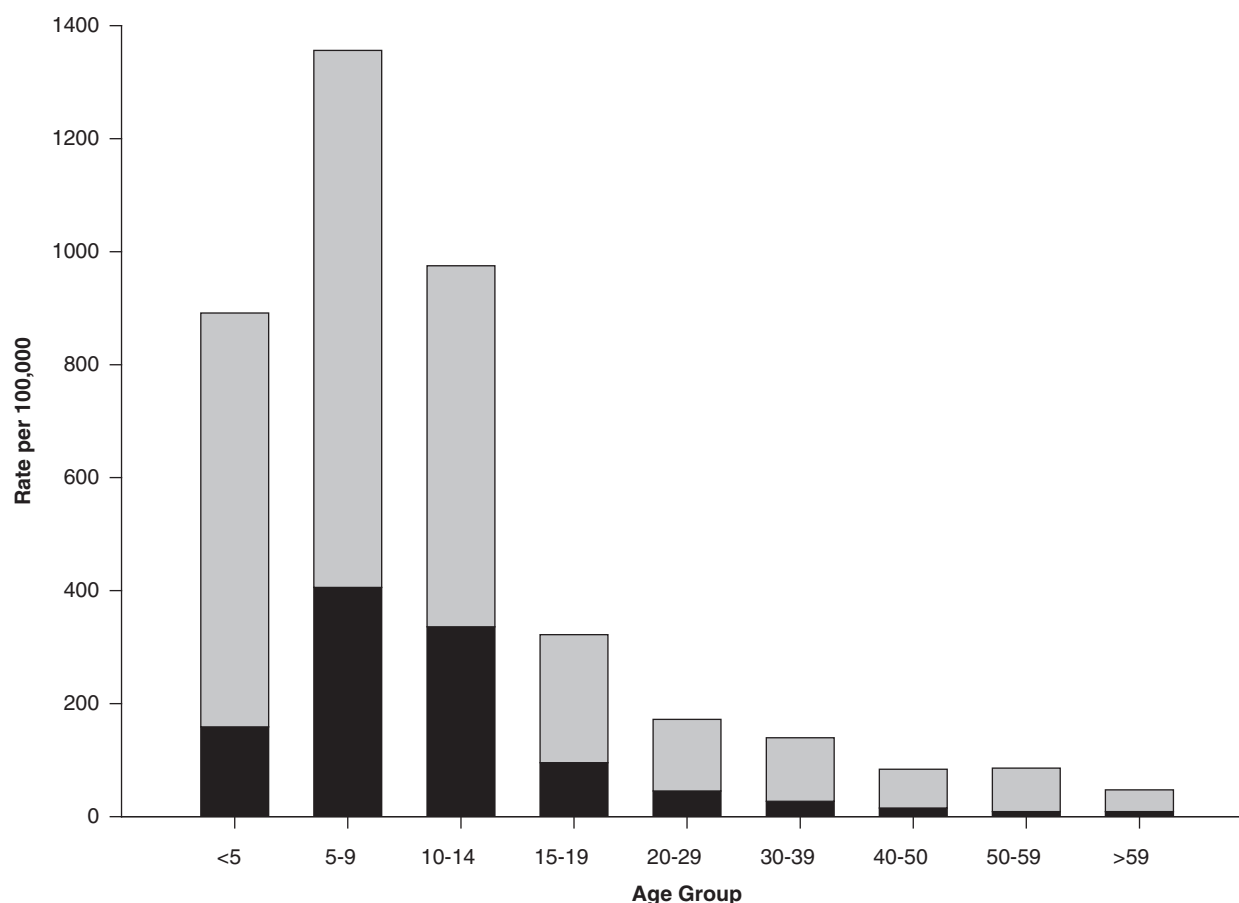
Figure 3. Age distribution of ILI (gray) and RIDT A-positive (black) cases in the Cameron County, Texas, influenza outbreak, April-May 2009


data presented a complete picture in both time and space as the epidemic evolved. Since the availability and use of RIDTs was at the local physicians' discretion, and because the confirmatory testing was at the discretion of state or national agencies, local public health officials had no control over either data source, and the national confirmatory data were too much delayed for any practical use in outbreak management.

Furthermore, the sensitivity of RIDT tests is now known to be lower for the 2009 H1N1 than for seasonal influenza viruses,[22] and in any event it was not done for many cases. Other than as confirmation of the circulation of a new strain, H1N1 laboratory results had little local relevance, and many cases were never tested. Having more rapid and local or regional laboratory identification for future epidemics is an important goal. ILI reports without individual follow-up turned out to be sufficiently accurate for our purposes, in addition to being simple, inexpensive, under the control of the local public health authority, and easily obtained (Figure 2). The trends seen in the ILI-based epidemic curves were further supported by simple daily review of absences from schools and daycare facilities and selected clinics and hospitals.

National and state reports that emphasized and appeared to accept as indicators only the confirmed cases created confusion within the lay community, partly because at one point there were more ILI cases reported in Cameron County than there were nationally confirmed cases. It was difficult for critical decision makers such as school officials to reconcile the hundreds of ILI cases in Cameron County they were seeing with the small number of officially confirmed cases at state and national levels.

We believe that our report also confirms the importance of collaborations between different government agencies, community groups—in our instance, county and city health departments, a school of public health, the University of Texas-Brownsville, local schools, adult and child daycare facilities, hospitals, clinics, and county government—in establishing effective surveillance and response to the local epidemic. In our case, preexisting projects and ongoing relationships allowed for rapid joint action. We were fortunate that the overall disease severity in this epidemic was mild, and thus, difficult problems, such as triaging in hospitals and expanded intensive care facilities, did not generate greater concern in the population.

Figure 4.   Real-time attendance and illness tracking during the epidemic, April 27 to May 15
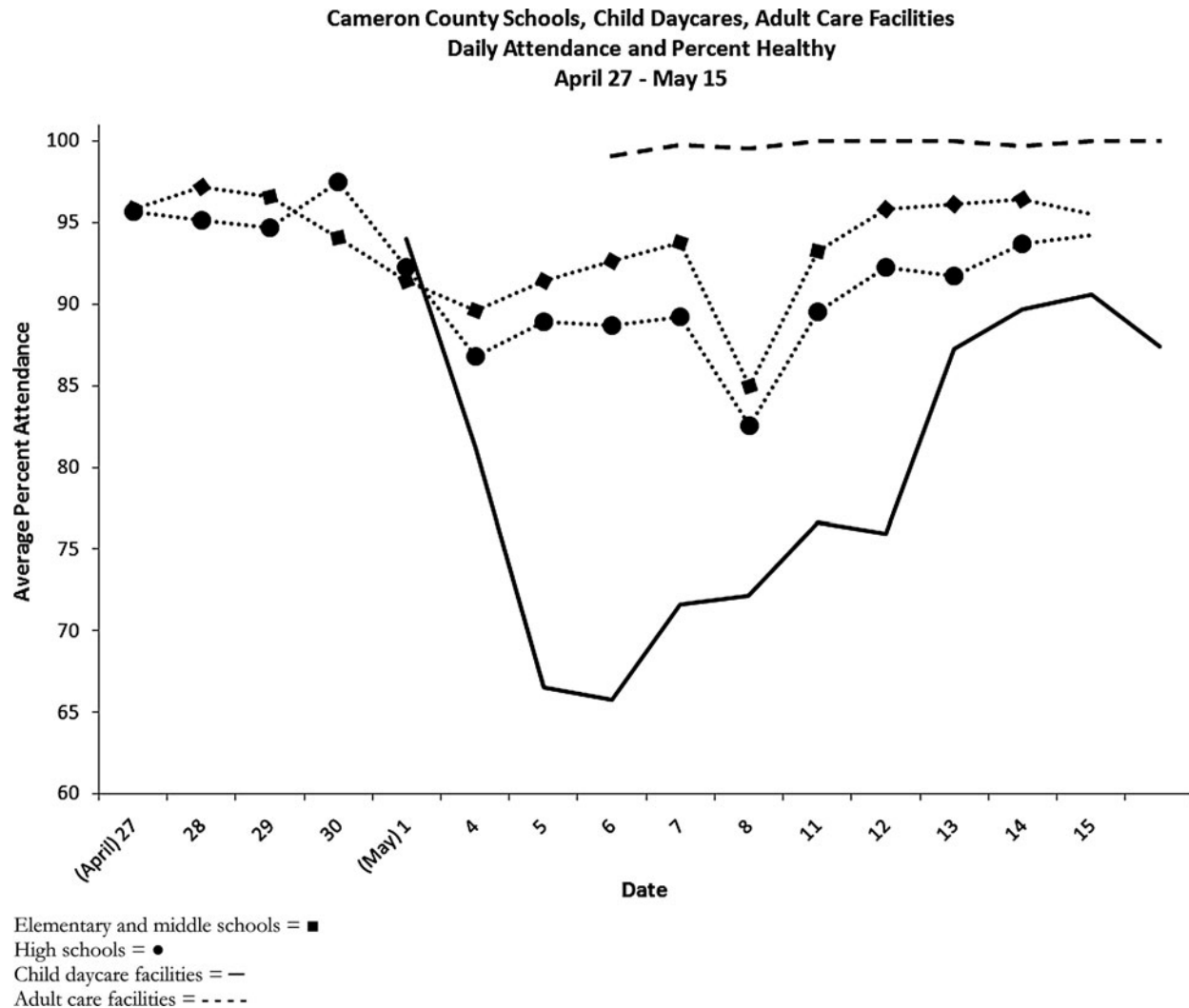

Collaborations such as the one we describe would be even more important in the event of a severely disabling epidemic. The Public Health Foundation and the Association of Schools of Public Health have begun to address these issues.[23,24] Thus, we recommend that preparedness plans encourage and even fund the development of these relationships so that they can be easily activated in the event of a much more virulent epidemic. Indeed, we believe that without them a clinically severe epidemic will be administratively, socially, and politically unmanageable.

We faced a multitude of problems at the local level. Necessary changes in local reporting requirements complicated already strained communications among local, state, and national health officials. The initially distributed 17-page questionnaire caused confusion and loss of data, but it was quickly replaced at the state level. While clinic-based disease surveillance is important for tracking and managing an epidemic, it is not, in its current form, an ideal method for detecting the onset of an epidemic. We showed that this

can be greatly enhanced by using school surveillance, where we saw a dramatic dip in elementary school attendance on April 27, preceding other alerts and supporting our impression that 2009 H1N1 was likely already circulating in Cameron County earlier in April 2009. Significant changes must be made at the state and national levels to improve outbreak detection and surveillance and to connect national reporting with local reporting. In the 2009 H1N1 epidemic, there was no relationship between the two.

We also found that real-time data can be analyzed with geospatial software to create daily informational maps, which were useful in tracking and managing the epidemic. Our daily maps allowed us to target education and response resources to areas of highest impact. Another benefit of real-time surveillance was that we knew long before national reports emerged that this was mainly an epidemic in children, with few cases among the elderly, and that this was a mild disease with few hospitalizations. We shared our daily reports with school districts and discussed them with the

Figure 5. Cumulative spatial mapping of the Cameron County H1N1 influenza outbreak showing highest incidence in the urban areas close to major border crossings (marked with bidirectional arrows). Color images available online at www.liebertonline.com/bsp.
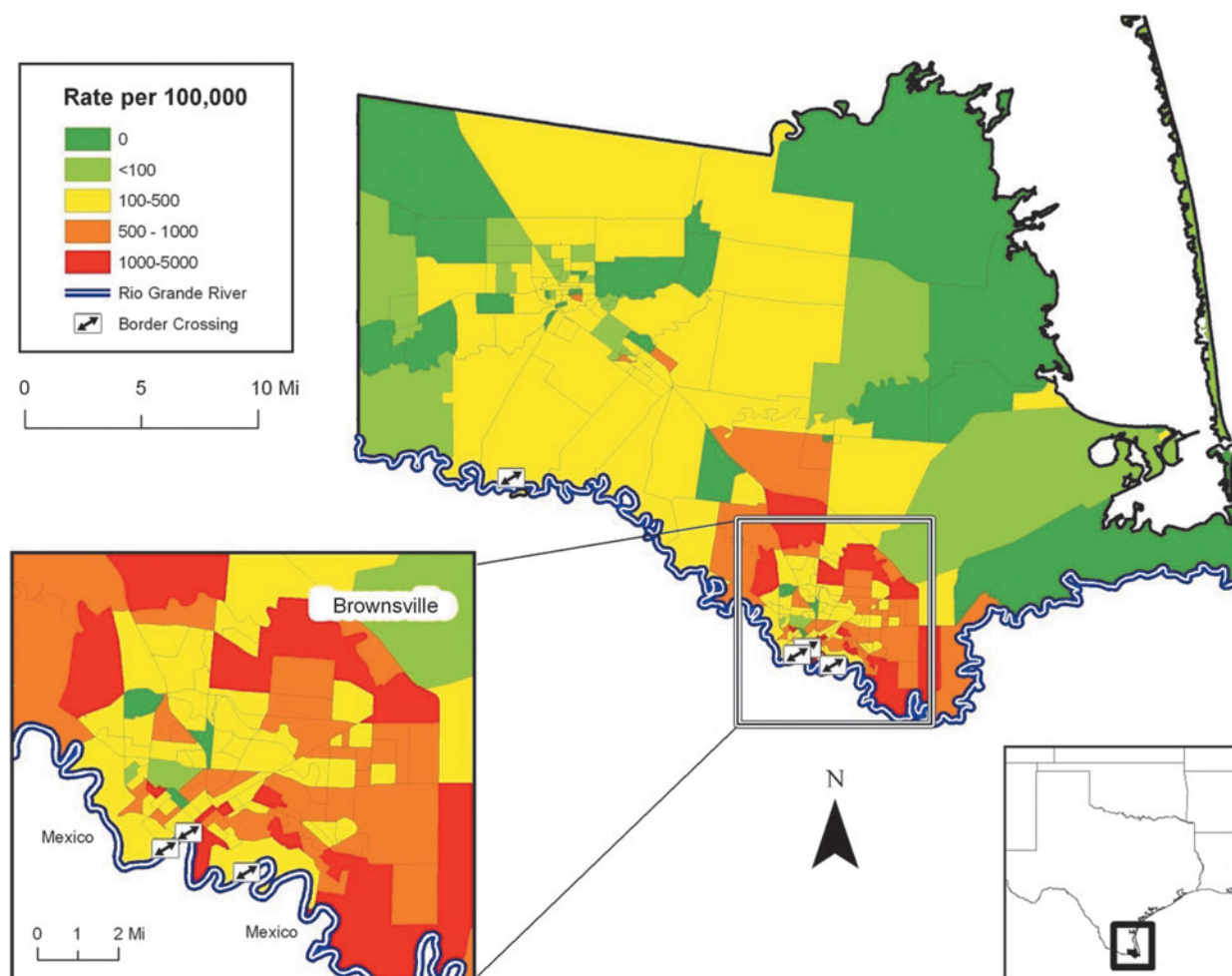
superintendents and with the county judge, who used them to consider school closures. These exchanges also established lines of communication with institutions so that we could help answer questions and provide feedback of data to the entire community.

CONCLUSION

Influenza pandemics continue to be unpredictable and threatening; therefore, more thought needs to be given to developing preparations at the community level that more effectively connect local and national surveillance information. Innovative yet simple approaches using tracking of web-based communication strategies have already shown that use of available data can be very effective in tracking outbreaks, including the 2009 H1N1 outbreak.[25]

Despite extensive influenza planning and training efforts at the county level, the classic system was adjusted in this outbreak to local circumstances to become more workable. Had this epidemic been the highly pathogenic H5N1 avian

strain, the consequences would likely have been far worse. Simple surveillance systems using readily available data sources need to be in place at the community level with clear, uncomplicated instructions tailored to those who are in a position to take action, such as health officials, school districts, and daycare facility administrators. More efficient communication and flexibility to meet the challenges of a new pathogen outbreak and fewer elaborate formal requirements would allow a more flexible and timely response and maintain the confidence of the community. We are fortunate that this outbreak of a mild illness allowed us to test and evaluate our pandemic management systems. Our community-based experience should help to develop a simple but robust local detection and response to future outbreaks.

ACKNOWLEDGMENTS

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